

Index

a

“absorbed fraction” 327
 activity 15ff, 26ff, 85, 157ff, 177, 195, 199, 205ff, 213ff, 227ff, 231ff, 246f, 251ff, 266ff, 377, 402, 419
 – becquerel (Bq) 16
 – curie (Ci) 16, 19
 – sample 92, 216, 217, 228
 – specific 18, 19, 27, 213, 214
 – TRUE 206, 217, 232, 234
 – mean 217, 236
 alpha decay 9
 – alpha particle 4, 9, 144ff, 251ff, 276
 – spectrum, alpha particle 9
 analysis of variance (ANOVA) table 367
 annual limits on intake 327
 ANSI/HPS N13.30 248
 anthropomorphic phantom 248, 327
 atomic theory, semiclassical 3ff
 attenuation coefficient 214, 317ff
 – linear 214, 317, 319ff, 324, 334
 – mass 318, 320, 321, 333
 attenuation processes 320
 – Compton scattering 3, 5, 12, 276, 277, 320, 321, 323ff
 – pair production 3, 320
 – photoelectric absorption 3, 12, 321, 323ff
 – photoelectric effect 5, 320, 322
 – photonuclear reaction 320
 Auger electrons 276
 avalanche 279
 average life 17, 60
 average, weighted 306, 392, 413, 415
 Avogadro’s number 18

b

Bayes factor 406ff, 409, 413, 418, 420
 Bayes’ Theorem 43
 Bayesian statistics 393

Becquerel 4, 16
 Bernoulli 22, 92, 172, 186, 192, 306, 407
 – process 22, 92
 – trial 92, 94, 112, 114, 186
 Bernoulli distribution 92, 93, 192
 beta decay 9, 12
 – antineutrino 9
 – beta particle 9, 12, 17, 77, 291
 – spectrum, beta particle 9
 beta distribution 154
 bias, systematic 249, 371
 binding energy 274, 325
 binomial 93
 – approximation to hypergeometric 107
 – cumulative distribution 94, 96, 407
 – distribution 15, 16, 22ff, 29, 78, 85, 91, 93ff, 99, 100, 104, 106, 114ff, 135, 136, 139ff, 159, 164, 216, 224, 407, 408
 – normal approximation 135, 136
 – Poisson approximation 100, 141
 binomial distribution 15ff, 22ff
 binomial series 24
 blank, appropriate 248, 249, 253, 255
 Bohr 4, 6, 11
 Bragg-Gray chamber 300
 bremsstrahlung 276, 325

c

calibration 164, 216ff, 231, 238, 249ff, 253, 272, 380, 418
 calibration problem 380
 Cauchy distribution 89, 123, 150, 157, 161, 192
 cell killing 341ff
 cell survival 341ff
 – aberrations, exchange-type 347ff
 – clonogenic 342
 – curve 341ff
 – probability 341ff

- central limit theorem 124, 132, 160, 162, 172,
 175, 181, 210, 216*ff*
 Chadwick 8
 characteristic function 192
 characteristic X-ray 9, 276
 Chauvenet's criterion 263*ff*
 Chebyshev's inequality 76*ff*, 87*ff*, 96,
 128, 158
 chi-square distribution 142, 145*ff*, 160, 164,
 168, 183, 184, 412
 – additivity, property of 148, 149
 – degrees of freedom 146*ff*
 – normal approximation 147
 – quantiles 146
 – relation to gamma distribution 146
 – relation to standard normal
 distribution 148
 chi-square testing 145, 271, 281
 chord length 300*ff*
 – Cauchy theorem 311
 – distribution, isotropic 300*ff*
 classical laws 1*ff*
 – of electromagnetism 2
 – of gravitation 2
 – of mechanics 2
 – of motion 1*ff*
 – Newtonian mechanics 2
 – of physics 2
 – of thermodynamics 2
 – “ultraviolet catastrophe” 2
 classical statistics 387
 coefficient of variation (CV) 164
 Compton 3, 5, 12, 276*ff*, 320*ff*, 327
 – distribution 276
 – edge 276
 – scattering 3, 5, 12, 276*ff*, 320*ff*
 Compton scattering 3, 5, 12, 276, 277, 320,
 321, 323*ff*, 327
 – attenuation processes 320
 – Klein-Nishina formula 324
 conditional probability 21, 38*ff*, 44, 69*ff*, 87,
 145, 319, 333, 387
 – Bayes' Theorem 43
 – definition 39
 confidence interval 169
 – for difference in means 176*ff*, 196
 – for difference in proportions 181
 – for means 168
 – for Poisson rate 175
 – probable error 170, 195
 – for proportions 172
 – for ratio of variances 184
 – standard error 169
 – for variance 183
 conjugate prior distribution 396*ff*, 399*ff*, 414,
 419, 423
 continuity correction factor 137*ff*, 141, 159
 correlation 71, 353, 369, 381*ff*
 – coefficient 381
 – coefficient, sample 381
 correlation, coefficient of 71*ff*, 381*ff*
 count 106, 144, 169, 176, 195, 199, 202*ff*, 210,
 214*ff*, 231*ff*, 248*ff*, 266*ff*, 271, 281, 284*ff*, 317,
 322, 402, 416
 – background 215*ff*
 – gross 204, 215, 216, 218, 219, 222, 226, 228,
 232, 239, 267
 counter 102, 144, 228*ff*, 231, 267, 271*ff*, 300,
 314, 331
 – gas proportional 272, 274*ff*, 279
 – operation, chi-square testing of 281
 – scintillation 271
 counter, gas proportional 272, 274*ff*, 279, 293,
 300
 – dosimetry, applications in 300
 – microdosimetry, applications in 300
 – Rossi 300
 – spherical 300
 – tissue-equivalent 300
 covariance 71*ff*, 87, 90, 200, 359, 365, 381
 credible interval 404
 critical value, L_C 231*ff*, 236, 243, 263, 268
 cross section, macroscopic 317, 327, 329
 – mean free path, inverse 319, 327
 – neutron 327
 cumulative distribution function 53*ff*, 57*ff*,
 66, 84*ff*, 88, 121*ff*, 318, 404
 cumulative normal distribution 125, 126,
 128, 140, 147, 148
- d**
- Davisson-Germer 5
 de Broglie 5*ff*
 – momentum 7
 – wavelength 8
 de Moivre, Abraham 132
 dead time 284*ff*
 dead time correction 271, 284*ff*
 decay 1, 4, 7*ff*
 – constant 15, 17, 21, 23, 26*ff*, 60, 61, 143,
 144, 161, 176, 205, 21, 223, 315, 319, 387
 – disintegration 12, 15*ff*, 46, 106, 198, 224,
 253
 – exponential 15*ff*, 26, 315, 372
 – radioactive 1, 4, 7*ff*, 15*ff*, 22, 26, 29, 61, 99,
 102, 140, 143*ff*, 214, 216, 223, 224, 231, 315,
 322
 – rate 16, 17, 102

- decay probability 16, 23, 225
 decay time sampling 315
 decision level, L_C 233, 241, 248ff, 270
 delta theorem 210
 derived air concentrations 327
 derived quantity 199, 201, 202
 detector 228, 232, 234, 236, 237, 250, 271ff,
 275ff, 284, 285, 287, 290, 317, 322, 376
 – “energy proportional” 272
 – Fano Factor 273, 274, 277, 290
 – linear response 278
 – nonparalyzable 284ff, 290ff
 – observed resolution of 274
 – paralyzable 284ff, 291, 292
 – resolution of 271ff, 290, 291
 – response function of 272ff, 279
 – scintillation 276ff, 280, 290, 291, 321
 – semiconductor 274, 276, 280, 281, 290
 – sodium iodide crystal scintillator 276, 277,
 280, 281, 291, 320
 discrete uniform distribution 91, 92, 167, 398
 distribution 15ff, 51ff, 65ff
 – Bernoulli 92, 93, 192
 – beta 154ff, 161, 391, 392, 394, 395, 407, 420
 – binomial 15, 16, 22ff, 29, 78, 85, 91, 93ff, 99,
 100, 104, 106, 114ff, 135, 136, 139ff, 159, 164,
 216, 224, 407, 408
 – Cauchy 89, 123, 150, 157, 161, 192
 – chi-square 142, 145ff, 160, 164, 168, 183,
 184, 412
 – conditional 70
 – cumulative 53ff, 57ff, 66, 84ff, 88, 121ff, 318,
 404
 – discrete uniform 91
 – exponential 142ff
 – F 151ff
 – gamma 142ff, 155, 159, 396, 397, 399,
 410, 411
 – Gaussian 124, 132
 – geometric 110
 – hypergeometric 106ff
 – independence 66
 – joint 65ff
 – lognormal 153ff
 – multivariate hypergeometric 109
 – negative binomial 112
 – normal 3, 15, 26, 89, 102, 124ff, 133, 135,
 136, 139, 140, 147ff, 154, 157, 161, 164, 168,
 169, 171, 173, 177, 189, 190, 215, 216, 221,
 232, 242, 247, 248, 251, 258, 260ff, 269, 272,
 290, 359, 361, 381, 414, 418
 – Poisson 15, 26, 98ff, 114ff, 141, 143, 144,
 160, 164, 166, 167, 176, 187, 191, 193ff, 204,
 215, 216, 223ff, 231, 248, 251ff, 269, 273, 282,
 283, 289, 290, 396, 410, 411, 416,
 417, 421
 – posterior 84, 390ff, 403ff, 422
 – prior 84, 387, 390ff, 397ff, 406ff
 – standard normal 124ff, 128, 131, 148ff, 157,
 169, 173, 177, 201, 218, 232, 237, 243, 245,
 247, 248, 263, 332
 – Student’s t 89, 123, 149ff, 161, 170, 171,
 179ff, 183, 195, 247, 248, 257, 258, 264ff, 269,
 364, 366, 368, 377
 – uniform 91ff, 119ff, 156, 160, 167, 194, 295,
 301, 308, 324, 328, 331, 335, 391, 392, 395ff,
 402, 407, 408, 419, 420
 – of values 15
 distribution, probability 8, 51ff, 91, 92, 94,
 109, 111ff, 119, 121, 122, 124, 137, 148,
 165, 186, 283, 312, 313, 387, 388,
 390, 394
 – discrete 52, 67, 72, 91ff, 167, 398, 404
 – cumulative 54, 55ff, 61, 62, 65, 66, 84, 85,
 88, 94, 96, 97, 100, 102, 119ff, 136, 137, 148,
 252, 313ff, 324, 331, 332, 334, 407
 DOE Laboratory Accreditation Program
 (DOELAP) 255
 dose 1, 242, 245, 255ff, 264, 266, 269, 270,
 275, 293, 294, 317, 322ff, 334, 337ff,
 378, 385
 – absorbed, per unit fluence 322, 323, 325,
 326, 334, 343, 345, 349
 – committed 327
 – LD₅₀ 343, 344, 348ff
 – mean lethal 343, 344, 348
 – minimum 337
 – model 327
 – threshold 337
 dose-response 1, 260, 337ff
 – curve 338ff
 – function 340ff
 – relationship 338ff
 dosimeter, thermoluminescence (TLD) 114,
 159, 242, 255ff
 dosimetry 122, 255, 260, 261, 269, 293, 300,
 327, 328
 – internal 327
 – using gas-proportional counter 300
- e**
- effects, biological 337
 – deterministic 337
 – and exposure, radiation 337
 – genetic 337
 – germ cells 337
 – radiation induced 338
 – severity and dose 337

- somatic cells 337
 - stochastic 337
 - efficiency, counter 106, 210, 213, 214, 217, 219, 222, 225*ff.*, 232, 234, 236, 237, 250, 277, 278, 291
 - Einstein 2, 5, 9, 11
 - "God does not play dice." 11
 - special theory of relativity 2
 - electron-hole pair 271, 276, 280
 - energy resolution 271*ff.*, 276, 280, 281, 290, 291
 - error 163
 - estimated 173, 174
 - mean square, *MSE* 359*ff.*, 366*ff.*, 371, 373, 376*ff.*
 - random 163
 - standard 168
 - sum of squares for, *SSE* 359*ff.*, 367, 368, 371, 374*ff.*, 384
 - systematic 163, 164, 193, 199, 249, 271
 - error in an estimation 174
 - error propagation 199
 - analysis 279
 - in confidence interval of mean 201
 - in derived quantity 201
 - in mean 201
 - in standard error 201
 - error propagation formulas 202
 - exponentials 203
 - products and powers 202
 - sums and differences 202
 - variance of mean 203
 - error, systematic 164, 193, 249
 - estimate, interval 168, 169, 407
 - estimate, point 165, 168, 170, 177, 186, 403, 407
 - estimated error 173
 - estimation 145, 163*ff.*, 231, 253, 354*ff.*, 358*ff.*, 365, 376, 387
 - least squares method 354
 - estimator 165
 - consistent 166
 - efficient 166
 - generalized maximum likelihood 403
 - maximum likelihood 186*ff.*, 197, 361, 362, 390, 403, 407, 422
 - minimum variance unbiased 166
 - pooled, for variance 178
 - standard error 173
 - unbiased 165
 - event 33
 - complement 34
 - exhaustive 41*ff.*
 - independent 21*ff.*, 38*ff.*, 322
 - intersection of 34
 - mutually exclusive 34*ff.*, 41*ff.*, 46, 47
 - probability 36
 - simple 33
 - union of 33
 - expected value 27, 59*ff.*, 63, 69, 72, 74, 85, 89, 92, 95, 99, 105, 165, 166, 189, 190, 192, 198, 200, 209, 224, 227, 229, 232, 267, 295*ff.*, 314, 330, 331, 362, 365*ff.*, 371, 373, 396, 397, 419, 420
 - experiment 29
 - exponential distribution 85, 142*ff.*, 159, 160, 197, 198, 286, 289, 315*ff.*, 320, 398, 419
 - arrival time for first Poisson event 143
 - memory 99, 145, 319, 320
 - relation to gamma distribution 142
 - relation to radioactive decay 142
 - extrapolation 364
- f**
- F* distribution 151
 - degrees of freedom 151
 - quantiles 151
 - relation between upper and lower quantiles 152
 - false negative (type II) error 235
 - false positive (type I) error 233
 - Fano factor 273, 274, 277, 290
 - fiducial limits 378, 379
 - film, radiosensitive 255
 - finite population correction factor 107, 109, 116, 134
 - Fisher, R.A. 381
 - frequency, relative 302*ff.*, 313, 387
 - frequentist 387*ff.*, 393, 403*ff.*, 407, 412
 - full width at half maximum (FWHM) 272*ff.*, 290
- g**
- gamma distribution 142*ff.*, 155, 159, 396, 397, 399, 410, 411
 - gamma ray 9, 11, 12, 276*ff.*, 291, 319*ff.*, 327, 328, 341
 - gas multiplication 272, 279
 - Gauss, Carl Friedrich 132
 - Gauss-Markov theorem 359
 - generalized maximum likelihood estimator 403
 - geometric distribution 110
 - GM tube, self-quenching 290
 - goodness-of-fit 119, 353
 - Gosset, W.S. 151
 - gram atomic weight 18*ff.*

h

half-life 12, 15ff, 19ff, 25, 27, 28, 62, 106, 140, 206, 207, 211, 213, 224, 225, 227, 333, 344
 Heisenberg 5, 6
 – quantum mechanics 5
 – uncertainty principle 5ff, 12
 highest posterior density (HPD) 404, 407
 high-purity germanium (HPGe) 228, 276, 280, 281, 290
 hypergeometric distribution 106
 hypothesis 240
 – alternative 240, 241, 243, 245ff, 270, 368, 408, 409, 414
 – composite vs. composite 240
 – null 240ff, 257, 258, 270, 367, 405
 – simple vs. composite 240
 – simple vs. simple 240
 hypothesis testing 240

i

importance sampling 309
 increment, independent 320
 Independence Theorem 44
 independent event 44
 independent variable 304, 306, 308, 353, 368, 369, 373, 376, 382, 383, 385
 inference, Bayesian 403
 inference, statistical 84, 231, 366, 387
 integral calculus, fundamental theorem 56
 interpolation 364
 ion pair 274ff, 281, 290
 – average energy, W , to produce 275
 ionization 270ff, 274ff, 279
 – device 271
 – potential 274

j

joint probability function 65ff, 186

k

Klein-Nishina formula 324

l

lack of fit 369, 371, 373ff, 383
 laws of quantum physics 2
 – definite 2
 – statistical 2
 L_C 231ff, 236, 243, 263, 268
 – critical value 231
 – decision level 248
 L_D 237, 238, 250ff, 258ff, 266, 269, 270
 – minimum detectable true net count number 237
 – lower limit of detection, LLD 237

– minimum detectable amount, MDA 237, 248, 250ff, 269

LD_{50} 343, 344, 348ff
 leakage, radiation 322
 LET spectrum 300
 lifetime, average 17, 60
 likelihood function 186ff, 197, 262, 361, 388ff, 392, 394, 403, 410, 414, 419, 420, 422
 linear energy transfer (LET) 294, 300, 327, 341, 348, 351
 – distribution 294
 – quality factor 327
 – spectrum 300
 lognormal distribution 153
 lower limit of detection, LLD 237

m

marginal 66ff, 72, 84, 86, 87, 89, 391, 394
 – density 66, 67, 69, 70, 84, 86, 87, 89
 – distribution 67, 68, 72, 86, 391, 394
 maximum likelihood estimator (MLE) 186ff, 197, 361, 362, 390, 403, 407, 422
 Maxwell 4
 mean 59ff
 mean square error, MSE 359, 364, 392
 mean, correction for 355
 median 62ff, 86, 89, 161, 165, 292, 332, 334, 403, 404, 407ff, 416, 417
 Medical Internal Radiation Dose (MIRD) Committee 327
 memory 99, 145, 319, 320
 microscope, scanning tunneling 10
 Millikan 4
 minimum detectable amount, MDA 237, 248, 250ff, 269
 minimum detectable true activity, A_{II} 235ff, 241, 242, 258, 267
 minimum detectable true net count number, L_D 237

minimum significant measured activity, A_I 231ff, 238ff, 266, 267
 minimum variance unbiased estimator (MVUE) 166ff, 188, 189, 194
 mode 403, 404, 407ff, 416, 417, 420
 modeling, biological 338
 – cross section 342
 – extrapolation number 347, 349, 350
 – for stochastic effects 338
 – hits per target, average number of 342
 – linear quadratic 347
 – multi-target, multi-hit 347
 – multi-target, single-hit 345, 346
 – single-target, single hit 342
 moment 189

- generating function about point b 192
- generating function for a sum of random variables 193
- generating function 191
- j^{th} 190
- j^{th} , of the sample 190
- method of 189
- momentum 4*ff*, 11, 77, 335
- Monte Carlo method 122, 293*ff*, 340
- to determine absorbed dose 294, 323, 325, 326, 334
- to determine dose equivalent 293
- to determine dose 293
- to determine LET distribution 294
- to determine shielding properties 293
- in dosimetry 293
- in energy losses 293
- in flight distances 293
- in neutron transport 293
- in photon transport 317, 319*ff*
- in radiation penetration 293
- in radiation physics 293
- Russian roulette 329
- in scattering angles 293
- splitting 329
- multiplicative rule 44
- multivariate hypergeometric distribution 109

- n**
- negative binomial distribution 112, 113, 115, 117, 396, 419
- net dosimeter reading 256
- Newton 1
- Neyman-Pearson Lemma 262
- noninformative prior distribution 397*ff*, 410, 414
- Jeffreys 410*ff*
- location parameter 398
- reference 397
- scale parameter 398
- vague 397
- nonparalyzable detector 284*ff*, 290*ff*
- normal equations 355, 369, 371
- normalize 61

- o**
- outlier 263
- overdispersion 253

- p**
- pair production 3, 320
- paralyzable detector 284, 285, 287
- parameter 164
- partitioning of counting times, optimum 222

- q**
- quantum mechanics 5*ff*, 52, 53, 56

- r**
- radiation, isotropic 89, 117, 122, 157, 300
- radioactive decay 1, 4, 7*ff*, 15*ff*, 22, 26, 29, 61, 99, 102, 140, 143*ff*, 214, 216, 223, 224, 231, 315, 322

- radiobioassay 248*ff*, 255, 269
- radionuclides, short-lived 223
- random number 293*ff*
- generator 92, 122, 294, 295, 302, 308, 316, 330
- seed 294
- sequence 295
- randomness, test for 295
- rate, count 106, 144, 204, 205, 210, 215*ff*, 226*ff*, 232, 236, 250, 267, 271, 284*ff*, 317, 318, 322, 402
- background 216, 217, 227
- gross 204, 205, 216, 218, 219, 222, 226, 228
- net 215, 217, 220*ff*, 227, 228, 232, 233, 236, 249, 267
- rate, event 285
- ratio of variances estimator 184
- reconfirmation 373
- region 240
 - acceptance 240
 - critical 240
 - rejection 240
- regression 259, 260, 269, 353*ff*
 - inverse 353, 378*ff*
 - linear 353*ff*
 - through origin 376
- regression analysis 353*ff*
- relation between gamma and beta distributions 154
- relative error 106
- relativity, special theory of 2
- repeat observations 373
- residual 358
- residual, minimum sum of squared 358
- response variable 353*ff*
- risk 327*ff*
 - and acceptable radiation limits 340
 - assessment 327
 - estimation 338
- Roentgen 3
- Rule of Elimination 41
- Rutherford 4

- s**
- sample size estimation 174
- sample space 29*ff*, 51, 82
 - continuous 32, 33, 37
 - discrete 32, 33, 36, 37, 51
 - element, individual 29
 - outcome 29
- sampling 107
 - decay times, from exponential distribution 315
 - from known distribution 313
- importance 309
- stratified 308
- with replacement 107
- without replacement 107
- sampling distribution 132*ff*, 149, 158, 159, 166, 168, 169, 171, 173, 194, 393*ff*, 398*ff*, 402, 403, 417
- Satterthaite's approximation 180
- Schrödinger 5
- scintillation 271
 - counter 271
 - photon 272
- scintillation detector 276*ff*, 280, 290, 291, 321
- lanthanum bromide, cerium activated [LaBr (Ce)] 280
- sodium iodide, thallium-doped [NaI (Tl)] 228, 276, 277, 280, 281, 291, 320
- scram 410
- semiclassical physics 4
- semiconductor detector 274, 276, 280, 281, 290
- cadmium zinc telluride [CdZnTe] 280, 281
- high-purity germanium (HPGe) 228, 276, 280, 281, 290
- set 33
 - empty 33
 - null 33
- smoothing techniques 306
- specific activity 18, 19, 27, 213, 214
- spectrometer, alpha particle 251*ff*
- standard deviation 63*ff*, 95*ff*, 106, 124*ff*, 132*ff*, 144, 154, 156*ff*, 164, 168*ff*, 173, 193*ff*, 202, 210*ff*, 216*ff*, 222*ff*, 232*ff*, 242*ff*, 249, 264*ff*, 273, 291, 307, 315*ff*, 330, 402, 420, 422
- net count rate 217
- standard error 168
- standard error of the mean 133, 195
- standard normal distribution 124*ff*, 128, 131, 148*ff*, 157, 169, 173, 177, 201, 218, 232, 237, 243, 245, 247, 248, 263, 332
- statistic 165
 - sufficient 415
 - test 240
- statistical inference, methods 387
 - Bayesian 387*ff*, 398, 403*ff*, 410
 - classical 387
 - frequentist 387*ff*, 393, 403*ff*, 407, 412
- stratified sampling 308
- strong force, short range 327
- Student's *t*-distribution 149
 - degrees of freedom 149
 - quantiles 150
 - relation to Cauchy distribution 150

- sum of cross products 355
 - corrected 355
 - uncorrected 355
- sum of squares 355, 359, 361, 367, 371, 374, 383, 384
 - corrected 355
 - due to regression, SSR 367
 - for error, SSE 359
 - lack of fit 374, 383
 - pure error 374, 383
 - uncorrected 355
- sum of squares due to regression, SSR 367
- sum of squares for error, SSE 359
- sum of squares lack of fit 374
- sum of squares pure error 374
- sum of squares, corrected 355
- sum of squares, uncorrected 355
- support 80
- survival probability 16, 20, 21, 23, 26, 143, 322, 341, 342, 346, 348

- t**
- Taylor series expansion 199
- test 241
 - most powerful 262
 - one-sided 245
 - one-tailed 245, 246
 - power curve for 241
 - power of 241, 242, 373
 - significance level of 241
 - size 241
 - two-tailed 245, 246
- test statistic 240
- Theorem of Total Probability 41ff
- Thomson 4
- time 290
 - dead 271, 284ff, 289ff
 - real elapsed 290
 - system live 290
- transformations of random variables 77ff
- transformation, radioactive 9, 16
- transmutation 4
- transport, photon 317
 - linear attenuation coefficient 317
 - mass attenuation coefficient 318
 - Monte Carlo 122, 293ff, 340
 - in shielding calculation 317ff
 - under good geometry 52, 317, 318
- tunneling 9

- u**
- type I error 233ff, 241, 243, 249, 252, 257, 263, 266, 267, 269

- v**
- variable, random 36
 - continuous 36
 - discrete 36
 - expected value 27, 59ff, 63, 69, 72, 74, 85, 89, 92, 95, 99, 105, 165, 166, 189, 190, 192, 198, 200, 209, 224, 227, 229, 232, 267, 295ff, 314, 330, 331, 362, 365ff, 371, 373, 396, 397, 419, 420
 - independent 304, 306, 308, 353, 368, 369, 373, 376, 382, 383, 385
 - mean 59ff
 - mode 403
 - response 353ff
- variance 63ff, 71ff, 84, 87, 89, 92, 94ff, 105, 107, 110, 113ff, 120, 135, 142, 145, 146, 151, 154ff, 159ff, 164ff, 170ff, 183ff, 189, 194ff, 208ff, 217, 222, 232, 240, 247, 248, 250, 253, 256ff, 262, 270, 273, 274, 282, 308, 309, 316, 317, 353, 354, 358, 359, 361, 364ff, 369, 371ff, 376, 377, 385, 391, 393, 400ff, 414ff, 419, 422
- interval estimate 183
- of a linear combination of variables 74
- pooled estimator for 178
- Venn diagram 35
- von Laue 5

- w**
- wavelength 2, 4ff, 11, 291
- wavelengths, distribution of 2
- wave-particle duality 5
 - photoelectric effect 5
 - X-ray diffraction 5
- whole-body count 251

- x**
- X-rays 3, 5, 9, 164, 211, 276, 320, 334, 338, 340